Forestcast Season 2: Backcross- Episode 2: How Do You Breed Better Trees?

Audio Transcript

Jonathan Yales

Welcome back to Backcross, the story of how resistance breeds restoration. This is Part 2, and I'm Jon Yales.

The first side of our two-sided story is the resistance breeding side, the forest genetics side. And, where better to start than with a geneticist?

Jennifer Koch

I call myself a jack of all trades, and master of none. My official title is 'Research Biologist,' but my masters and PhD are both in molecular genetics.

Jonathan Yales

After my trip to Delaware, Ohio, I called Jennifer Koch, the forest geneticist there, to ask what even is resistance?

Jennifer Koch

That's, actually, a complicated question.

Jonathan Yales

Yeah?

Jennifer Koch

It causes a lot of debate. But, the one thing that came to mind to me was COVID. The majority of people [who] get infected tolerate the infection quite well and the infection doesn't do very much damage to them. But, in a certain percentage of people, the virus actually activates the immune system, sending it into overdrive—and we've all heard about that cytokine storm that then can do damage to your own body and make things much worse. So, that would be a person that would have low tolerance to the virus because the virus is having more impact on them.

Jonathan Yales

Mhmm

Jennifer Koch

A resistant person would be a person who can prevent the virus from replicating to the point that it is doing damage to them. There's actually an example in trees, of a similar phenomenon, where an insect can induce defense responses in a tree, and the defense responses in the tree end up being detrimental to the tree. So, a commonly known defense response in a tree is called a hypersensitive response, and

that's when the tree starts to kill cells around the infection point to limit the spread of the pathogen—and that can also be triggered by insects—but there also has to be signals in the tree to now stop killing cells, too. So, if that defense response—or that hypersensitive response—begins and is out of control, the tree can end up killing its own tissue. So, that would be an example of a tree that is not tolerant to infection or infestation by an insect, but a tree that didn't have that hypersensitive response would be more tolerant in those examples. That's what I'm saying, it gets very complicated.

Jonathan Yales

Yeah. And, kind of bouncing out of that and bouncing to the trees, like, do all trees have resistance? When you are looking or thinking about breeding, does it exist [for every species] and that's what we're going with for every single species, we're trying to find that tree that kind of pushes back against the pathogen, an insect, whatever, a little more than the other ones? Does it exist everywhere, or no?

Jennifer Koch

So, there's been arguments made that if a tree did not co-evolve with an insect or a disease that it may not have resistance, but what we're saying is that when you have trees, for example—I'm going to rely on ash as an example a lot because that's what I work with so much—ash grows on all but one continent across the world, and some areas ash has co-evolved with EAB and other areas it hasn't. And, if you think back through history, at some point these continents were connected and then they separated, and there's evolution occurring, so the different ash species probably evolved from a common parent, sort of, species. Plus, they also have evolved defenses to the native insects that are similar to emerald ash borer, so you do find resistance that has developed, maybe to a native insect, maybe it's just a carry over from that common ancestor, but it's just really uncommon because there's no selective pressure to increase it in the population. Or, in some cases it's a defense response that evolved to something completely different that can be unrelated to the actual insect attack. So, an answer to your question, to my knowledge, and I don't know everything, but in every experience that I've had, when people have been able to carefully look for resistance, they have found it.

Jonathan Yales

Now, what do we even do with this resistance? Well, the trees that find themselves at risk of extinction, it can become a life raft to species survival. But, to utilize it, we have to breed, and we have been, but more so out West than out East.

Jennifer Koch

There's some western species that there's programs that have been going on there for 50 years. All of our programs are really relatively new. Chestnut is probably the oldest program, but that was not a breeding program done within the Forest Service. It’s been funded by the Forest Service, and the Forest Service has had a role. But, the elm breeding work didn't start until the, probably about, 2008—it was all selection work prior to that back into the 1930s.

Jonathan Yales

Yeah.

Jennifer Koch

Beech work started in 2001. Ash breeding started in about 2004. So, these are all very new, but we've got 50 years worth of breeding in southern pines, in western pines, in Port Orford cedar, where we have examples of species that were actually—their level of risk of extinction has been decreased as a result of resistance programs, and identifying resistance within those species. So, we've tried to hold that up as an example, and saying, this is, you know, this works, we know this works, we have a long history of this working.

Jonathan Yales

Breeding has been big—and has worked before—out West, but it's historically been to make better trees for lumber purposes, or to fill in things after wildfires.

Jennifer Koch

Out West, because they have these forest fires that require massive restoration efforts, it's sort of built into the whole Forest Service anyway. They have the pipelines, they're used to doing plantings to restore after forest fires. So, getting improved material planted out is not that big of a deal.

Jonathan Yales

But, back here in the East, we have our own problems.

Jennifer Koch

But, I would say that the invasive insects are the forest fires of the East, as far as the impacts that they're having on our forests.

Jonathan Yales

So, we too, in the East have been breeding, as Jennifer said. Sometimes to combat insects. Sometimes diseases. Sometimes to save a species. But also, sometimes, just to make the tree like they once were.

Jennifer Koch

So, for chestnut, the breeding work has been done by The American Chestnut Foundation. And, of course, we don't have fully resistant chestnut yet. But, chestnut is, however, one of the ones that is completely threatened with extinction. Now, Elm is also, again, very different. Elm is at no risk of extinction—at all. Elm is doing quite well. It is impacted by a disease. What the real demand is on the side of the public, is that they want to see those gorgeous, big street elms, and that is a horticulture cultivar development thing, but it's not saving a species from extinction, like, chestnut is.

Jonathan Yales

Yeah.

Jennifer Koch

Ash is interesting because even though there has been a delay, it is going to end up being one of the programs that was the quickest to respond with breeding. So, most of the breeding programs have been—they did not start until decades afterwards. So, that's sort of, like, one of our big messages that we've been working on is to try to bring breeding to the forefront of: Okay, biocontrol is good, we need

to learn about chemical control, even better yet—things I'm sure that Sandy (Sandy Liebhold - from season 1) talked about—is let's prevent these things from even getting here and causing damage in the first place, that's the holy grail, for sure. But, if it is here, you got to throw everything at it, but if we want to learn from nature—and I'm a big proponent of that—integrated pest management is best. We don't expect that biocontrol alone is going to work for ash because biocontrol alone doesn't work for ash in continents where it's native. You have both resistance and biocontrol, and together they reach this sort of equilibrium where everyone lives happily together without killing off a species.

Jonathan Yales

But, what does resistance breeding actually look like? Well, kinda like crops, but not exactly.

Jennifer Koch

It differs from crops because in crop breeding the goal is to have genetic uniformity—you want every single ear of corn to look the same, taste the same. But, in forestry, we need to take a population of trees and increase the level of resistance and the frequency of resistance, so that the population can survive—or enough of the population can survive—and carry enough genetic diversity forward into the next generation so that it can live long enough to reproduce, it can be self sustaining, and the progeny have enough genetic diversity that they can also survive other stresses that they're going to encounter in their lives. So, unlike that corn that's going to be replanted every year, trees have to be able to survive for hundreds or, you know, there's trees that even live thousands of years. So, over that period of time, they're going to see other stresses, there's going to be other insects—native, invasive—other pathogens, other diseases, there's going to be differences in the environment, they're going to have to endure droughts. So, the genetic diversity of the population ensures that enough of the population is going to survive each time one of those major stress events occurs, that it continues to evolve, and it's not going to risk becoming extinct.

Jonathan Yales

And, that's basically because there's less human touchpoints, as, obviously with crops or planting or farming, you're touching it—as you said, planting it every year or you're watering it, you're doing all these things that you can't do in a forest setting—so, therefore, when we do set something back out, it has to be able to survive a little longer. Is that what you're saying.

Jennifer Koch

Yeah. That's our goal with a lot of the threatened species like ash, is to save it from extinction. So, our first goal is not that we expect to put out populations of ash that are going to never be affected by EAB and are going to grow just as well as the ones that we're replacing. We're hoping to get populations with enough resistance that they can survive to reproduce and continue that road of natural selection and avoid extinction. In the meantime, yes, the breeding programs will continue to try to improve to put out even better seed, but the initial attempts will probably be reaching that bar of: can it survive long enough to reproduce?

Jonathan Yales

When I first started thinking about breeding, when I saw all those greenhouses and tree orchards back in Delaware, a part of me questioned: how different is this from an unnatural control like chemicals? The

straight-like-an-arrow rows of trees? The shortcuts we help the trees take? Isn't it all 'tinkering' with nature?

Jennifer Koch

That's the same as, you know, people that have houseplants—or like, succulents are really big now—you can just take a leaf off of a succulent and stick it in another pot and it'll root, right? It's the same concept as that. Or, people that are gardening, then they split their hostas and then they can plant them somewhere else, that's propagation. So, I don't think, you know, that's really not 'tinkering'—yeah, everything I just mentioned was not something that grows in nature, but I don't see that as severe 'tinkering' with nature. I think I view what we're doing as helping out nature by pushing along the process of natural selection. So, certainly by making these clonal, genetically identical copies, it's just a way of reducing risk and moving the tree into our greenhouses and in our plantings where it's safer for us to work with them, and also getting them close together so that they can breed with each other, because natural selection can only occur when there's enough trees left after the selection event has occurred, that they can reach each other and cross-pollinate. And, with EAB, there aren't enough survivor trees left that that's gonna happen. And that would be what would lead to eventual extinction. So, I see it as gene conservation, preventing extinction just by helping the natural process of natural selection. Somebody had coined that term 'tree harmony,' like the dating service for trees, we just help them find each other.

Jonathan Yales

And, you also mention, I think you termed it, 'assisted selection,' you know, 'assisting' nature, or 'accelerating' some of the processes. I mean, breeding is nothing but that, but obviously, it's all assisting.

Jennifer Koch

Yeah, definitely 'assisting' nature. And then, there's other things that we are doing to accelerate nature: trying different techniques to get trees to flower younger. And, this has been something that's been used for decades in apple trees, crop trees, nut [trees], all sorts of different types of trees. But, that's just so we can get the seed we need for restoration quicker. It's not something that is going to happen out in the forest that we're going to make all the trees that go out there produce seed quicker. It's just so that we can get the seed quicker, and it can be as simple as drought stress. If you just don't water a tree, trees have this natural instinct that they want to survive and keep their genetics out in the environment. So, anyway, it can be very simple, very natural processes to help accelerate seed production. So, I do think that everything that we're doing is very natural, and it is just assisting nature, and it's very, very different from any sort of genetic engineering.

Jonathan Yales

I saw one of your tweets. You said, 'It's not very often I get to visit my trees these days between COVID and having developed a contact allergy to them, but it's nice to see them.' One, so you—what's your allergy, you can not even like be around trees, like, how does that work?

Jennifer Koch

Yeah, it's happened with every species I've worked with. When I was in grad school, I worked with poplar, and I developed—it was a respiratory allergy to the volatiles. But, then it came back with a

vengeance a couple of years ago, where I was in the greenhouse and we use biocontrol to control different insect pests, because we can't use insecticides, and so, I was distributing it so that meant I was sticking my arms and my face through these ash seedlings and by the next morning I had what looked like poison ivy all over. And, I was like, thinking, I'm like, that's everywhere I touched the trees, it was my arms and my face. And, it got worse and worse. I went through three rounds of steroid shots, finally went to an allergist who figured it out. If I am around the trees, I use ivy wipes and the lotions you can put on to prevent poison ivy—it's just creating a barrier, and that works. And, I keep with me at all times the combination of three different antihistamines that, if I start having a reaction, I take. Because, the first time around, literally, it lasted close to six months. Big clumps of my hair were falling out because it went into what they call an autoimmune response. And so, that's where you get hives when you're not actually touching it. So, I had clumps of hair falling out. So, my staff is very understanding and I don't get on the watering schedule and go in and water the plants anymore. So, it's kind of sad, but I also said, too, that I want to stop doing this before I'm allergic to everything, because I like the outdoors; when I retire I would like to be able to go for a hike in the woods still.

Jonathan Yales

With this bit of understanding that we now have from Jennifer on the resistance breeding side of things, next, we're going to step into the restoration side of things. We'll dig into what the breeding, and restoration research, looks like for the American chestnut. Why we've lost —and miss— that tree so much, and what's still at stake.

Leila Pinchot

We've been working on it for so long, there's so much excitement—if we can't make it work for [American] chestnut, I don't know what species we can make it work for. So, it's really important just to have a success, because so many species are under attack by non-native pests and pathogens, we need a success to keep that momentum moving forward.

Jonathan Yales

In Part 3 of Backcross, we'll check in on the first of our three Eastern tree species that Jennifer and team are currently working to restore. First up: one of America's most missed trees.

James Mullins

You know, if they can go to the moon and everything, they should be able to restore that tree by now. Don't you believe that?

Jonathan Yales

I'm Jon Yales. Thanks for listening.

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Thanks for listening, and see you next week.